Research Article

Effects of Aerobic Exercise and Resistance Training on Stage I and II Breast Cancer Survivors: A Pilot Study

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ABSTRACT

Background: *Lack of physical activity has been noted in breast cancer survivors and been attributed to decreased physical function.* ***Purpose:*** *This study assessed the effects of a moderate-to-vigorous physical exercise program on body fat percentage, maximal oxygen consumption (VO_2 max), body mass index, and bone mineral density (BMD) of breast cancer survivors.* ***Methods:*** *Eleven stage I and II breast cancer patients, 40–65 years old, were recruited to assess VO_2 max, BMD, weight, and percentage of body fat before and after an 8-week exercise (aerobic and resistance training) intervention.* ***Results:*** *Supervised exercise significantly improved aerobic capacity (+4.227 ml/kg/min; P=0.004) and increased, though not significantly, bone mass densities of hip (+0.433 SD units; P=0.061) and spine (+0.224 SD units; P=0.350). No significant changes were observed for body mass index (+0.0196 kg/m^2; P=0.927) or body fat percentage (-0.737%; P=0.639).* ***Discussion:*** *Understanding how breast cancer survivors tolerate and respond to a moderate-to-vigorous exercise program is an important step in developing programs for this population following recovery.* ***Translation to Health Education Practice:*** *Moderate-to-vigorous physical exercise may be an effective and well-tolerated intervention for improving physical function in breast cancer survivors.*

BACKGROUND

Approximately every 2 minutes a woman in the United States is diagnosed with breast cancer. Last year, the National Cancer Institute estimated that more than 180,000 new cases would be diagnosed, with more than 40,000 women dying from the disease.

One common outcome during the treatment of breast cancer is decreased physical function.[1-3] For many patients, low physical performance imposes limitations on basic daily activities[2] such as the ability to work, meet the needs of one's family, or exercise. These limitations exacerbate the patient's debilitation and fatigue.[3-4] Regarding exercise in particular, research shows that breast cancer patients typically reduce their exercise levels after diagnosis and generally do not return to their prediagnosis activity levels once in the recovery phase.[1] Similarly, Frost and collegues[5] found significant differences among four patient groups (newly diagnosed, adjuvant therapy, stable, and recurrent) in the impact of breast cancer on one's ability to perform physical exercise. Lack of physical functioning also puts breast cancer patients at risk for other illnesses, including diabetes and cardiovascular diseases.[1,4]

Exercise is also tied to another key issue for breast cancer patients and survivors: bone health. Prolonged immobility and fatigue and reduced ability to perform weight-bearing exercise can put survivors at risk of developing osteoporosis.[1,6] Decreased bone mineral density (BMD) may also be linked to the anti-estrogen medications (e.g., aromatase inhibitors) used to treat breast cancer.[1,6] Chemotherapy can compromise bone health as well—in a pilot study of 30 breast cancer patients ages 42 to 65, 80% experienced osteopenia or osteoporosis within four years of receiving such treatment.[6] The study attributed this to early onset of menopause due to chemotherapy, the effects of adjuvant hormonal treatment, and a decrease in physical functioning.[6] Indeed, loss of BMD is a significant problem for women receiving breast cancer treatment, causing bone weakness that leads to a higher risk of bone fractures.[6] (Note: Published data on the risk of fracture following

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chemotherapy in particular are lacking, and preliminary results are inconclusive. Some studies show that women with breast cancer experience nearly five times greater risk of vertebral fractures than age-matched controls,[7] while others show that the incidence of hip fractures was 37% lower among breast cancer survivors compared to otherwise similar women.[8] Due to conflicting results, more studies are needed to understand the incidence of BMD loss and fractures in women with breast cancer.)

In addition to harming bone health, sedentary lifestyles among breast cancer patients and survivors can cause weight gain, which further compromises the recovery process. Weight gains between 2.5 to 6.2 kg are common for breast cancer survivors during the first year of prognosis.[9] Evidence suggests that postdiagnosis weight gain could adversely affect the risk of breast cancer recurrence,[1,9,10] and obesity has been linked to higher cancer stage at diagnosis, poorer chances of survival, and elevated risk of recurrence compared to women who maintained body weight.[11] In a study of 5,202 Nurses' Health Study patients, Kroenke and colleagues found that overweight patients (those who gained between 0.5 and 2.0 kg/m^2 or more than 2.0 kg/m^2 after diagnosis) had an elevated risk of breast cancer recurrence and mortality compared to women who maintained body weight.[12] Penedo and colleagues found that among women at least 20 years past menopause, those who gained 30 kg since age 18 had an odds ratio of 2.04 for breast cancer mortality compared to those who maintained their body weight.[13]

Evidence suggests that physical exercise, both aerobic and resistance-based, is an effective, well-tolerated, and highly rewarding behavioral intervention for increasing physical functioning, increasing BMD, and overcoming weight gain.[1-4,10-14] Studies show that women with breast cancer who follow the Centers for Disease Control and Prevention recommendations of exercising at moderate intensity for 30 minutes or more daily for 5 or more days a week may survive longer.[15] Dimeo and colleagues studied 70 cancer patients receiving high-dose chemotherapy. Study participants performed an exercise program of cycling on an ergometer at moderate intensity (50% heart rate max) for 30 minutes per day during hospitalization. Results showed that those participating in the exercise program experienced shorter hospital stays (P=0.03), with 27% less loss in maximal performance at discharge compared to a control group.[2] Segal and colleagues studied 123 stage I–II breast cancer patients divided into three groups: control, self-directed exercise program, and supervised exercise program. Those patients who participated in the supervised aerobic exercise program at moderate intensity (50–60% heart rate max) for 26 weeks while hospitalized showed less muscle atrophy and an increased aerobic capacity versus the control group.[3]

PURPOSE

Although researchers have begun to explore the effects of exercise on breast cancer survivors, little data has been generated regarding the effects of a supervised exercise intervention on maximal oxygen uptake (VO_2 max) in such individuals. VO_2 max is an indicator of the highest metabolic rate an individual can achieve with exertion and is considered to be the most objective physiological indicator of functional capacity.[16] The few studies that have assessed maximal oxygen consumption among breast cancer patients after exercise interventions have involved the patients performing cycle ergometry at low to moderate intensity. The present study sought to show that such patients could experience significant increases in physical fitness by exercising at a moderate to maximal intensity over 8 weeks, matching results seen in healthy individuals. In addition, this study added a resistance training component in order to examine the effects on BMD, body fat percentage, and body mass index (BMI). This article reports findings from a pilot study of the effects of a planned and monitored exercise program integrating aerobic exercise and resistance training on specific physiological parameters of stage I and II breast cancer survivors.

METHODS

Sample

Eleven stage I and II breast cancer patients, 40–65 years old, were recruited from the greater Charleston, South Carolina, area using flyers and word of month; all were referred by local oncologists. Stage I and II patients were chosen because cancers at those stages are still limited to the breast, rather than having spread to other parts of the body. Subjects enrolled in the study were sedentary (defined as less than 3 months since participation in weight training or aerobic activity) and without exercise limitations (i.e., current heart, physical, or other health conditions). All subjects were considered post-menopausal (defined as less than 1 year since the last vaginal bleed) at the time of the study. The Citadel's institutional review board approved the protocol, with signed consent obtained from all patients and their physicians before participation.

Procedure

BMI was computed as weight in kilograms divided by height in meters squared. Three BMI groups, as defined by the World Health Organization, were used: lean weight (BMI<25 kg/m^2), overweight (BMI=25.0-30.0 kg/m^2), and obese (BMI>30.0 kg/m2).[17] Percentage of body fat was measured using the "BOD POD" (Life Management Inc., Concord, CA). Subjects wore a nylon swimsuit and a nylon swim cap during testing and had abstained from exercise, food, and drink for at least two hours beforehand. Maximal oxygen consumption was assessed using the TrueMax 2400 Metabolic Measurement System (ParvoMedics, Salt Lake City, UT) with the Bruce protocol, a 7-stage event with treadmill incline (10–22% grade range) for 3-minute timed intervals at a speed range of 1.7 to 6.0 mph. BMD was measured from hip and spine scans using the 4500 Hologic DEXA (Hologic Inc., Waltham, MA). Three BMD groups for post-menopausal, Caucasian women, as defined by the World Health Organization, were used: normal (T-score 2.5 to -1 SD), osteopenia (T-score between -1 and -2.5 SD), and osteoporosis (T-score at or below -2.5 SD). These four physiological

Table 1. Characteristics of Study Sample

Characteristic	
Age (years)	
Mean	51
SD	6.1
Weight (lbs)	
Mean	153.7
SD	28.4
Height (in)	
Mean	65
SD	2.1
Race/ethnicity	Caucasian
Years since diagnosis	
Mean	4.4
SD	2.6

parameters were measured before and after the 8-week exercise intervention.

The exercise program consisted of aerobic exercise (elliptical trainer and running and/or walking at an incline on a treadmill) and resistance training (2 sets of 12–15 repetitions using free weights and Nautilus equipment). The intervention was divided into 2 stages, with the first stage comprising weeks 1–2 and the second stage comprising weeks 3–8. During the first stage, subjects participated in 20 minutes of supervised aerobic exercise and 10 minutes of weight training 3 days per week for 2 weeks. The second stage consisted of 30 minutes of aerobic exercise and 20 minutes of weight training 3 to 5 days per week for 6 weeks. Aerobic exercise was conducted at a target intensity of 60–85% heart rate max, which was initially assessed using a Polar heart rate monitor (Lake Success, NY). Resistance training included all major muscle groups of the upper and lower body along with abdominal and back conditioning. W4L Elite 5 Function Pedometers (Walk4Life, Plainfield, IL) were used to calculate the daily number of steps during the last 6 weeks of the study.

Data Analysis

The study's objective was to compare the pre- and post-test scores for each of the four physiological parameters (BMI, body fat percentage, VO_2 max, and BMD). Means and standard deviations were calculated for each parameter, and differences in means were compared using dependent t-tests on SPSS Version 10.1 for Windows (Chicago, IL).

RESULTS

All 11 of the study recruits completed the pilot 8-week exercise intervention. Descriptive characteristics of the subjects are summarized in Table 1.

Aerobic Capacity

Results indicated significant changes in maximal oxygen consumption between baseline and post-intervention (+4.227 ml/kg/min; P=0.004). Results are presented in Figure 1. A mean 16% improvement in functional capacity was achieved, as indicated in Table 2 (pre-test=26.009 ml/kg/min, post-test=30.236 ml/kg/min). All subjects except one improved their aerobic capacity, ranging from 7 to 37%. The one subject who did not improve over the course of the study actually exhibited a 20% decline.

Bone Mineral Density

All subjects underwent hip and spine scans. Changes in BMD during the 8-week period are listed in Table 2. Results indicated no statistically significant differences in mean BMD of the hip between pre- and post-intervention (+0.4327 SD units; P=0.061), but hip t-scores improved by 60% after the 8-week program. Both the mean baseline and the post-exercise BMD were in the normal range for hip (mean=-0.72, post=-0.29). Individually, 7 of the subjects improved their hip BMD during the study, while 2 showed no change and 2 deteriorated. For the latter two subjects, BMD decreased from 0.3 to 0.36. Among the 7 who improved hip BMD, the increases ranged from 0.1 to 1.9.

Results established no significant differences ($p<0.05$) between pre- and post-intervention for changes in spinal BMD. Although the difference was not statistically significant, a mean 22% improvement in spinal BMD was achieved. The mean baseline BMD was -1.0 (indicating osteopenia), while the mean after 8 weeks of exercise was -0.79 (which is within the normal range). Individually, 4 of the participants improved, 6 deteriorated, and 1 showed no change. For those who improved, the range of spinal BMD increase was 0.1 to 1.9; for those who deteriorated, the range of BMD decrease was 0.1 to 0.4. Results are shown in Figure 2.

Body Composition

Changes in body weight and composition during the 8-week period are listed in Table 2. There were no significant differences ($p<0.05$) between pre- and post-intervention measures of total body weight, BMI, body fat percentage, percentage of lean mass, lean weight, or fat weight.

Pedometer

Pedometer results indicated a significant 9% increase in mean number of steps from the first week of wearing a pedometer (week 2) to the last week (week 6) (week 2=8443 steps, week 6=9283 steps; P=0.046). Changes in total number of steps are listed in Figure 3.

DISCUSSION

Our study showed that moderate-to-vigorous physical exercise may be a positive adjunct therapy for breast cancer survivors, alleviating some of the negative side effects of breast cancer treatment such as reduced physical performance and decreased BMD. The pre- to post-intervention increase in maximal oxygen consumption demonstrated improved functional and aerobic capacity after aerobic and resistance training. This improvement in VO_2 max consumption was seen in all but one of the subjects, with a range of improvement from 2.1 to 9.3 ml/kg/min. The mean 16% increase in maximal oxygen consumption in this study is comparable to gains documented in other studies analyzing the effects of aerobic interval training on cancer patients' functional capacity. For example, MacVicar and colleagues16 reported a 21% increase in VO_2 max for patients using a cycle ergometer, versus a 2% decrease in non-exercising control patients and a 17% increase in exercising non-patients. Segal and colleagues[3] reported only modest gains of 2.5% in patients' aerobic capacity after

26 weeks, but their chosen exercise intensity (50–60% heart rate max) was lower than that used for the current study (60–85% heart rate max). The gains seen in our subjects are also similar to gains observed in a cancer-free normal population. Green and colleagues[18] reported a 15.6% increase in VO_2 max for non–breast cancer subjects after 8 weeks of aerobic exercise.[18] Further research is needed to determine the effects of aerobic interval training on a large sample size of breast cancer patients.

Increasing physical exercise, especially weight bearing activities, is a good strategy for maintaining bone health and preventing debilitating falls and fractures.[1,4,19] Maintaining or improving BMD in the spine and hip is important for postmenopausal women because each decline in BMD of one SD is associated with a twofold increase in fracture risk.[19] In this study, participants showed 60% improvement in hip BMD and 22% improvement in spinal BMD after only 8 weeks of aerobic and resistance training. Such increases are consistent with the findings of other studies. Swenson and colleagues6 found that participants' BMD improved with a home-based strength- and weight-training program, while Waltman and colleagues[18] reported significant improvements in dynamic balance, muscle strength for hip flexion, hip extension, knee flexion, and BMD of the spine and hip. The current study's increase (nearing significance) in hip BMD might be attributed to the emphasis on the large muscles of the lower extremities during aerobic and resistance training. More studies are needed to examine the most beneficial intensity, duration, frequency, and type of strength training exercises for improving bone health.

This study's failure to produce significant changes in total body weight, BMI, body fat percentage, lean weight, or fat weight after 8 weeks of aerobic and resistance training is not consistent with other studies that have focused on the effects of exercise among breast cancer patients. Previous studies[1,3,8,10-13] reported improvements in body composition. Segal and colleagues[3] reported that patients in a supervised 26-week exercise program experienced a 1.4 kg weight loss. McTiernan and colleagues1 conducted an 8-week pilot study analyzing the effects of thrice-weekly monitored aerobic exercise sessions and a low-fat (20% of calories from fat) diet. Subjects lost an average of 2.6 pounds of body weight and 2.3% body fat. It was interesting to note that

Figure 1. Changes in Mean Aerobic Capacity (VO_2 Max ml/kg/min)

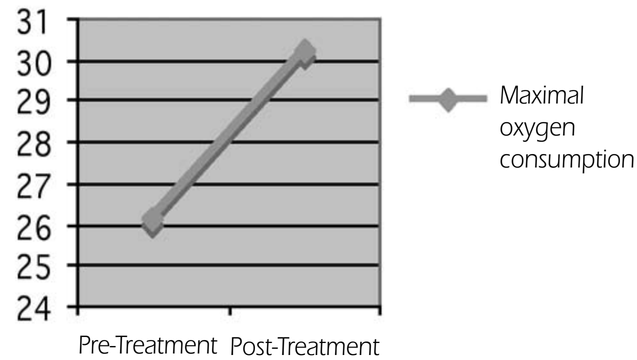

Figure 2. Changes in Mean Bone Mass Density (T-Score)

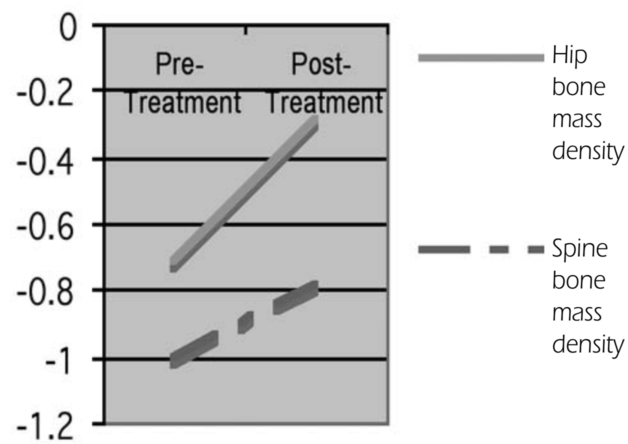

Figure 3. Changes in Pedometer Totals (n = 11)

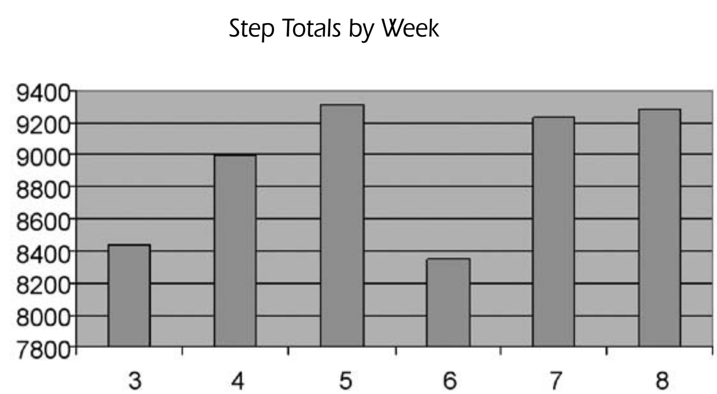

Table 2. Overall Changes from Baseline to Post-Intervention

Characteristic	Pre-Intervention	Post-Intervention	Percentage Change
Aerobic capacity (ml/kg/min)			
Mean	26.1	30.2	16%
SD	4.5	6.4	
Total hip T-score			
Mean	-0.72	-0.29	60%
SD	1.2	1.2	
Total spinal T-score			
Mean	-1.0	-0.79	22%
SD	0.84	0.76	
Weight (lbs)			
Mean	153.7	153.7	0%
SD	28.4	25.9	
BMI			
Mean	25.9	25.9	0%
SD	5.5	5.1	
Body fat percentage			
Mean	36.7	37.5	0.02%
SD	8.4	6.5	
Lean mass percentage			
Mean	63.3	62.5	0.01%
SD	8.4	6.5	
Fat weight (lbs)			
Mean	58.1	58.8	0.08%
SD	21.8	19.5	
Lean weight (lbs)			
Mean	95.7	94.9	0.01%
SD	10.4	8.5	

the one subject in the current study who did follow a self-directed dietary intervention (<20% of calories from fat) did lose 3.3% body fat, 7.6 lbs of body weight, and 5% BMI, which is consistent with the reported findings of McTiernan and colleagues. Our assumption is that body composition (e.g., percentage of body fat, BMI, and total body weight) would have improved if all subjects had participated in an exercise-diet intervention, particularly one longer than 8 weeks.

The primary limiting factor in this pilot study was the small number of subjects. It was our hope to recruit more subjects and include a control group as well, but the limited number of interested subjects prevented this. One of the most positive aspects of the study was that once subjects signed up, they were committed for the duration. Nevertheless, finding them was difficult. Recruitment took place over several months and included attending several breast cancer survivor meetings in the greater Charleston area, posting flyers in doctors' offices, speaking with several hospitals and their oncology staff, and sharing with research colleagues at the university hospital in Charleston. In speaking with others who conduct research among breast cancer survivors, we have discovered that this is not an uncommon problem. And despite this limitation, our conclusions are helpful in highlighting directions for future research and the importance of exercise interventions in this population.

Another factor that may seem limiting was the study's short timeframe. Although this may be true for studies assessing changes in body fat, this study's intention was to determine whether 8 weeks was an adequate time period to produce changes in VO_2 max with this population. Although research shows that changes in maximal oxygen consumption can occur within 8 weeks in healthy individuals, we were uncertain whether this was applicable to breast cancer survivors.

TRANSLATION TO HEALTH EDUCATION PRACTICE

Breast cancer patients typically reduce physical activity levels after diagnosis and generally do not return to prediagnosis activity levels once in the recovery phase.[1] Prolonged immobility, decreased physical performance, fatigue, and reduced ability to perform weight-bearing exercise can cause weight gain, BMD loss, and decreased aerobic function.[1,6,9] The resultant sedentary lifestyles can be very detrimental to breast cancer survivors, putting them at increased risk of cancer reoccurrence, decreased quality of

life, and other negative factors. However, a strategy of increasing physical activity has not been vigorously pursued among breast cancer patients and survivors due to a lack of understanding about its possible effects. This pilot study showed that physical activity can produce positive health effects among this population, including significant increases in aerobic capacity and non-significant increases in bone mass density of the hip and spine. It is therefore imperative that health professionals and educators facilitate physical activity (aerobic and resistance training) within this population.

Of practical application to future interventions, this study found that adherence to physical activity was enhanced by two factors: group exercise and the wearing of pedometers. The participants overwhelmingly noted that, when they exercised with others from the study, they enjoyed the activities more, were much more likely to attend the exercise sessions, and boasted about the positive effects of physical activity on their self-esteem and stamina. At the end of the pilot program, 8 subjects continued the study's regimen at the exercise facility of their own accord. This study also found that pedometers helped increase activity levels, as seen from the data. One possible reason for this increase may be the change in subjects' motivation levels. Subjects noted that, when given the pedometer, they were motivated to increase their activity levels during the day in the hope of reaching the recommended 10,000 steps per day. Thus, as shown with other populations, health practitioners and educators may find that group exercise and the use of pedometers are effective ways to encourage physical activity among breast cancer patients and survivors, thereby diminishing the secondary health implications of decreased physical activity.

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